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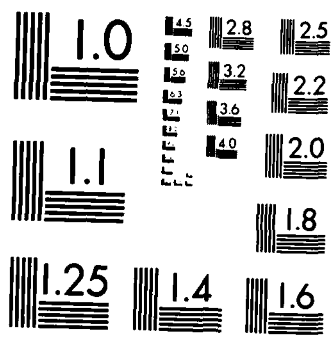
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USERS GUIDE FOR OPTIMUM INTERPOLATION METHOD
OF GLOBAL DATA ASSIMILATION

Donald C. Norquist

Systems and Applied Sciences Corporation (SASC)
1577 Springhill Road, Suite 600
Vienna, Virginia 22180

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AIR FORCE GEOPHYSICS LABORATORY
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This technical report has been reviewed and is approved for publication.

ALLAN J. BUSSEY
Contract Manager

FOR THE COMMANDER

ROBERT A. McCLATCHEY, Director
Atmospheric Sciences Division

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This report is a manual for using the codes that produce the ASAP optimum interpolation global data analysis. It describes the procedures for running the codes and indicates necessary input and output files and their forms. It describes what variables need to be changed for desired changes in resolution, time and date of analysis, and other changes and where these variables are located in the codes. Also described are procedures for running the AFGL global spectral model and non-linear normal mode initialization in sequence with the analysis procedure to form the data assimilation cycle. The manual is designed to accompany code listings available from the author.

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A. Description of the ASAP Data Assimilation Procedure

The AFGL Statistical Analysis Program (ASAP) Data Analysis Procedure (DAP) was designed to produce sequential forecasts and analyses of the global atmosphere. Originally, the ASAP analysis, patterned after the NMC optimum interpolation (OI) analysis detailed by Bergman (1979)[1], McPherson et al. (1979)[2], Kistler and Parrish (1983)[3], and Dey and Morone (1983)[4], was developed to provide initial conditions for the AFGL global spectral model (GSM) described by Brenner et al. (1982).[5] The analysis procedure was designed to work with the GSM and the Machenhauer non-linear normal mode initialization (NMI) described by Ballish (1980)[6] to provide accurate model forecasts.

In order to produce a forecast for a desired date, an analysis must be available for the starting date of the model integration. This analysis is a blend of observations with a previous forecast, which in turn depends on a previous analysis. Thus, before generating any long-term forecasts for a particular set of dates, sequential analyses based on short-term forecasts must be available as initial conditions. These analyses are produced by a data assimilation procedure consisting of a short-term (say, 6-hour) forecast and an analysis, followed by an initialization, another forecast, and so on.

The overall structure of the ASAP DAP is illustrated in Fig. 1. Table 1 lists the DAP computer codes by their permanent file name (PFN) and indicates which computer they are presently designed to operate on.

---

1. Bergman, K. H., 1979: Multivariate analysis of temperature and winds using optimum interpolation. Mon. Wea. Rev., 107, 1423-1444.

2. McPherson, R. D., K. H. Bergman, R. E. Kistler, G. E. Rasch, and D. S. Gordon, 1979: The NMC operational global data assimilation system. Mon.Wea. Rev., 107, 1445-1461.

3. Kistler, R. E., and D. F. Parrish, 1983: Evolution of the NMC data assimilation system: September 1978-January 1982. Mon. Wea. Rev., 110, 1335-1346.

4. Dey, C. H., and L. L. Morone, 1983: Evolution and performance of the National Meteorological Center Global Data Assimilation System: January-December 1982. Submitted to Mon. Wea. Rev.

5. Brenner, S., C. H. Yang, and S. Y. K. Yee, 1982: The AFGL Spectral Model of the Moist Global Atmosphere: Documentation of the Baseline Version. AFGL-TR-82-0393, Air Force Geophysics Laboratory, Hanscom AFB, MA, ADA129283.

6. Ballish, B. A., 1980: Initialization, Theory, and Application to the NMC Spectral Model. Ph.D. Thesis, University of Maryland, 151 pp.

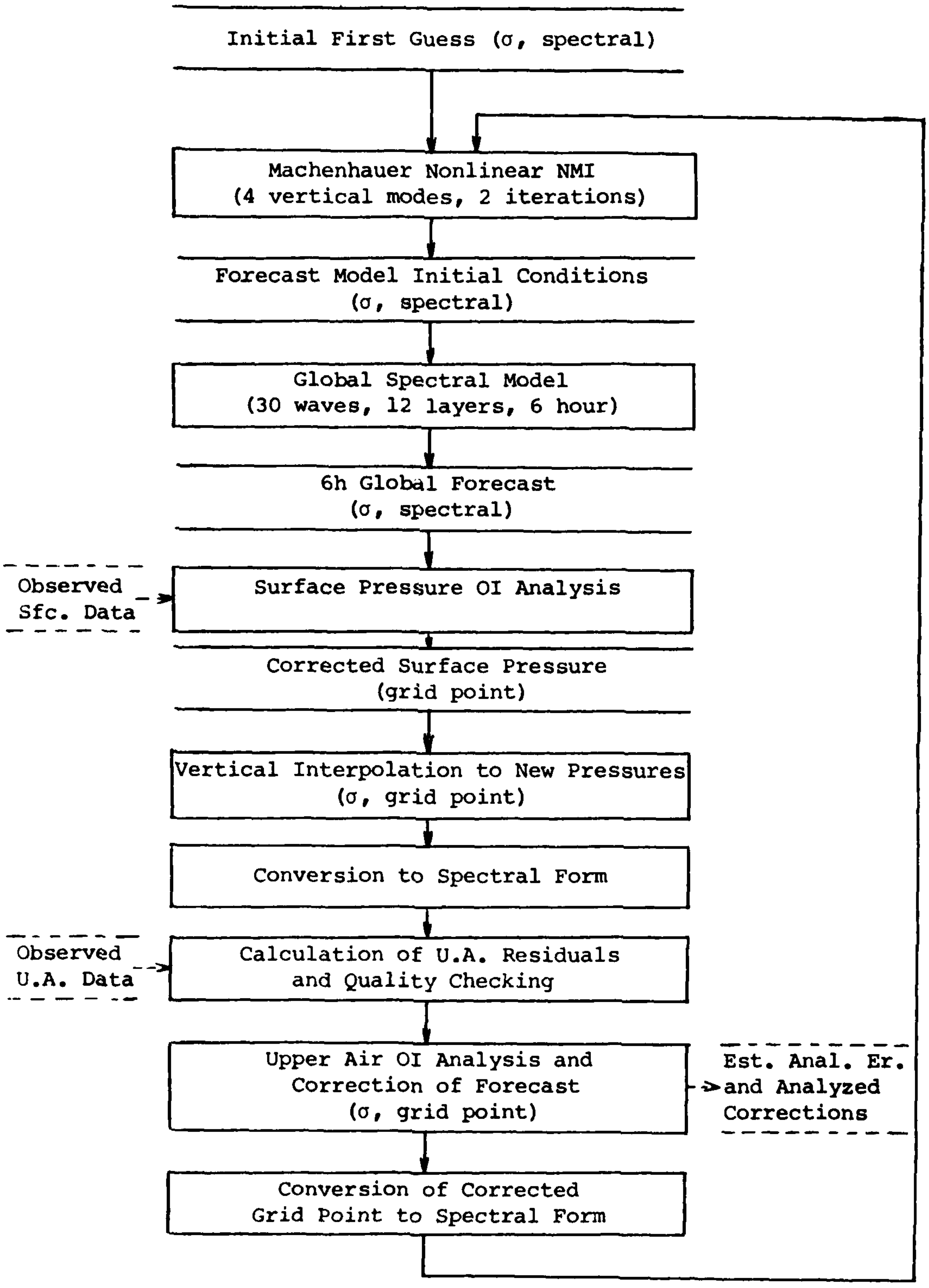

Fig. 1. Flow Chart of ASAP Data Assimilation Procedure

Table 1. DAP Computer Codes

PFN	Computer	Function
GNM	Cray	Machenhauer Nonlinear Normal Mode Initialization
FF	Cray	Global Spectral Model
PRESPOI PRESFPRSOI	Cray AFGL Cyber	Converts output from FF to grid point form
SPX SFPRSOI	Cray AFGL Cyber	Performs the surface pressure OI analysis
PREASAP PREASAPOI	Cray AFGL Cyber	Vertically interpolates grid point T, u, v, q to new sigma layer pressures and converts these to spectral form, then rederives grid point values
ASAPOI ASAPOI	Cray AFGL Cyber	Performs the upper air OI analysis (including calculation of residuals and quality checking)
POSTASAPOI POSTASAPOI	Cray AFGL Cyber	Converts analyzed grid point values to spectral form

B. Preparation of Inputs for DAP Components

The first step in preparing for an assimilation sequence is preparing the files that contain the observations. Both the surface pressure analysis and the upper air analysis require as input a file with all observation types on it. A description of the file created from extracting desired data from the FGGE II-B observation tapes is given in Appendix A(2). The program used to create this file on a tape is BFRDLS/UN=NORQUIS, and is used and stored on the AFGL Cyber. This program is described in detail in Appendix A(1). At present, the code is set up to create a tape of extracted FGGE II-B data for one date and time only. When a set of tapes containing the extracted observations for all analysis times in the assimilation sequence is constructed, it is mailed to the following address for storage in the Air Force Weapons Laboratory (AFWL) computer tape library:

Computer Tape Library
AFWL/ADOC
Bldg. 402
Kirtland AFB, NM 87117.

If the analysis segment of each cycle is to be run on the AFGL Cyber, the extracted observations (output from BUFF) can be stored on permanent file instead of tape if desired. When the tapes have been received by AFWL, the following job stream can be executed on the AFWL Cyber to create permanent files on the AFWL Cyber which can be "acquired" by the Cray for use in the analyses:

```
jobname,STMFB,NT1,T500.
ACCOUNT,username,charge code-HAN,AFGL,users phone #.
REQUEST,TAPE1,S,PE,VSN=tape name or number.
REQUEST,TAPE2,*PF.
BEGIN,STOSI,TACLIB,RB=64,NOFILE=10.
CATALOG,TAPE2,pfn,ID=user identification.
```

All CDC 6600 commands are upper case, whereas all Cray commands are lower case. In this job stream, the charge code is used to login to the AFWL CDC 6600: LOGIN, (login sequence identification). The AFGL tape name or number is the name or number affixed to the tape to identify it when sent to AFWL. Procedure STOSI converts "stranger" tapes to SCOPE Internal files for use in the AFWL CDC system. Note that since the output tape from BUFF contains 10 logical files, NOFILE is set equal to 10 for this application.

Once these files are created on the AFWL CDC 6600, each one may be transferred to the Cray by means of the "acquire" command when logged into the Cray: acquire dn=LFN,pdn=PFN,mf=fa,id=USER IDENTIFICATION,df=cb, where LFN is the logical file name you wish to refer to the file by on the Cray, PFN is the permanent file name on the CDC 6600, and the USER IDENTIFICATION is the same as the one you cataloged the file under on the CDC 6600. You may then store each file on the Cray's mass storage system (like cataloging it) once it is "acquired" by using the command: mass save LFN:MASSNAME where LFN is same as above, and MASSNAME (both typed in lower case) is the name of the file as it is stored in "mass".

If a new data assimilation sequence is desired for a date and time for which no previous sequence has generated an analysis, a starting analysis is required. In the recent ASAP Data Assimilation Experiment (Halberstam et al.,

1984)[7], a FGGE III-A analysis was used as a starting point. A series of five AFGL Cyber computer codes, detailed in Appendix B, is used to extract the 144 x 73 (2.5° latitude longitude grid) grid point set of data at 15 mandatory levels for Z, T, u, v, and RH and convert them to 30 wave rhomboidal (31 x 31) spectral coefficients of T, η (absolute vorticity), D (divergence), and q (specific humidity) on the 12 sigma layers, and of model terrain surface pressure. The spectral truncation as well as the number and distribution of the model sigma layers can be adjusted easily in the codes to match the model resolution. The resulting file of spectral coefficients, written in binary, must be converted from the form of the output of program GPTOSPTUVQPS (the last in the series) to the form required by the initialization code GNM. This is accomplished through the use of program ASTOGS, included as the sixth code described in Appendix B. The 30 wave spectral coefficients of the terrain height field are added on as the last record of the output from ASTOGS. This output file, in coded form, can be sent to AFWL on tape (in which case it should be written onto the tape in coded form, using a FORMAT (I5,F7.2,A4,A8) for the first WRITE statement in ASTOGS, and FORMAT(4(1PE20.13)) for the others; then, on the AFWL Cyber it can be transferred to a permanent file using the COPYCF utility), or it can be transmitted to the AFWL Cyber in binary form using the MILNET facility. If the latter procedure is used, the transmitted file must be converted to coded form before being "acquired" on the Cray for use in GNM. This can be done using a simple program on the AFWL Cyber in which each record is read in binary and written using the appropriate formats mentioned above. The coded output file is then ready to be transmitted to the Cray using the "acquire" command, and can be used directly as input to GNM to start the data assimilation sequence.

7. Halberstam, I. M., C. Johnson, D. C. Norquist, and S.-L. Tung, 1984: Two Methods of Global Data Assimilation . AFGL-TR-84-0260, Contract F19628-82-C-0023, Systems and Applied Sciences Corporation.

C. Running the Data Assimilation Procedure on the Cray

Procedures for running a complete cycle (CJREP) and a series of cycles (DNQOI) have been developed and are listed and discussed in Appendix C. Briefly, procedure DNQOI initiates the procedure CJREP repeatedly using sequential dates and times ddtt where dd is the date and tt is the Greenwich hour of day. The code ddtt for both initial and final times of the forecast in a given cycle are indicated. This lets CJREP know which cycle it is to perform. The observation file for the analysis as well as the form of SPX and ASAPOI for the designated date and time (both of these codes have date and time checks within them, so date and time must be set within the codes, and each of these stored separately in "mass") must have as the last four characters of its name in "mass" the proper ddtt values. The output files generated with the cycle (INIT<1>,GSM<2>, etc.) are then assigned these four characters where <1> refers to the first ddtt in each command of DNQOI, while <2> refers to the second ddtt code. The DNQOI procedure will need to be changed for each new data assimilation sequence (and versions of SPX<2> and ASAP<2> will have to be created and stored for each sequence), but CJREP will remain the same for all cases (unless the last sequence stopped before completing a cycle). The DNQOI procedure is put into action using the "submit" command (assuming the desired form of DNQOI resides on local file dnqoi): submit i=dnqoi,t=MM,cl=A,pr=S where MM is the number of minutes required to run all of the cycles in DNQOI (the sum of the number of minutes required for each cycle, indicated by the last number in each "cosmos" command in DNQOI) and A and S indicate the desired class and priority for the job respectively (see AFWL "BATCH" manual).

A description of the seven codes that make up the data assimilation procedure (see Table 1) is given in detail in Appendices D and E. Each of the codes as it is used in CJREP has several inputs and at least one output. At present, CJREP is constructed in such a way as to preserve six output files from each cycle:

init<1>	initialized fields for the ddtt of the forecast initial conditions
gsm<2>	forecast fields for the ddtt of the forecast time
mmmcor<2>	corrected grid point values of T, u, v, q for ddtt of forecast
coreae<2>	analyzed corrections and estimated analysis error for Z, u, v, q at grid points for ddtt of forecast

nmin<2>	analyzed fields for the ddtt of the forecast
postout<2>	spectral root mean square values for analyzed fields for ddtt of forecast

Several other files are stored in "mass" during the course of each cycle, but since they are not stored with a ddtt indicator, they are overwritten in the following cycle. The six files listed above were retained because of their importance in assessing the quality of the data assimilation procedure. A procedure (CJXXX) was developed to store four of the files (init<1>, gsm<2>, coreae<2>, and nmin<2>) for each cycle on a tape in coded form. Files init<1> and coreae<2> are in binary form, so CJXXX calls and runs programs (nmrw and mmx respectively) which re-write the files in coded form. Then CJXXX gets and executes <u>sis</u> and <u>sisin</u>, programs written by an AFWL consultant, which are available to all users, to place the coded files sequentially on a tape. The present form of CJXXX is given below:

```
*select savelog=1844, print log=log<3>
*select printlog=hsp
*interrupt on software error to err
*mass get nmrw tapel:init<1>
*mass get dir=/gcb1669/ctss sis sisin
*cft i=nmrw, b=bnmrw
*ldr bin=bnmrw, x=xnmrw
*xnmrw
*destroy tapel
*mass get gsm:gsm<2> tape3:coreae<2> nm:nmin<2>
*mass get mmx
*cft i=mmx, b=bmmx
*ldr bin=bmmx, x=xmmx
*xmmx
*cosmos i=sisin with 4 tape5 gsm tape6 nm / 5
*cosmos i=sis with citos 48 4 dnq<3> / 5
*goto
*err:
```

Type 4: Satellite Sounding Observations

These observations have the form of several records per observation. The following sequence of READ statements should be used to access the data on the file that contains Type 4 data:

```
   READ(1,5)ALAT,ALON,IDA,IHR,IDST,PCC1,P1,PCC2,P2,TS,PTROP,TTROP,QCTROP,
            NTYP1,NTYP2,NTYP3,NTYP4,ISCR,IQCI,IOP
 5 FORMAT(1X,2F6.2,3I2,2(F2.0,F3.0),F3.0,F4.1,F3.0,F2.0,4I2,2I1,I3)
```

The variables NTYP1,NTYP2,NTYP3,NTYP4 indicate how many layers of each type of sounding level are reported. Since there are two layers per record, the number of records present for each type is given by

```
   NREC1=(NTYP1+1)/2   there will be NREC1 records (in the form of the
     :        :        following READ statement) involving ITYP=01,
     :        :        followed by NREC2 records (in the form of
     :        :        the following READ statement)
   NREC4 = NTYP4+1)/2  involving ITYP=02, etc.
```

The records have the general form (where ITYP=01,02,03, or 04):

```
   READ(1,6)ITYP,QC1,PL1,PU1,V1,QC2,PL2,PU2,V2
 6 FORMAT(1X,I2,2(F2.0,2F5.1,F4.0))
```

The variables have the following definitions:

ALAT:	observation latitude to hundredths of a degree
ALON:	observation longitude to hundredths of a degree (in east long., 0° to 360°
IDA,IHR:	day and closest hour of the observation
lDSI:	data source index value (see Appendix A, Table I)
PCC1:	percent of effective cloud cover in first cloud layer (in percent)
P1:	pressure at average cloud top of first cloud layer (mb)

NOTE: The four digit numbers in parentheses following many of the descriptions above are code table numbers for tables in the following document: Manual on Codes, World Meteorological Organization, Vol. 1, International Codes, 1974 Edition, WMO Publication No. 306, available at the AFGL Research Library desk.

PZ: sea level pressure, station pressure, or geopotential height, depending upon value of KPCI (pressures are to tenths of mb, but geopotential heights must be multiplied by 10 to yield units of geopotential meters)

IQPZ: quality control for pressure/height value (see Appendix A, Table IX)

T: temperature of the observation to tenths of °C

IQT: quality control for temperature value (see Appendix A, Table IX)

DPD: dew point depression of the observation to tenths of °C

IQDPD: quality control for dew point depression value (see Appendix A, Table IX)

WD: wind direction of the observation in degrees

WS: wind speed of the observation in meters/second

IQW: quality control for wind values (see Appendix A, Table IX)

ITPPT: time period indicator for precipitation (indicates time period over which precipitation value applies) (see Appendix A, Table XII)

PT: magnitude of precipitation (mm)

WW: present weather (WW in sfc ob code) (4677)

CLM amount of low or middle clouds (N_h in sfc ob code) (2700)

C1: types of low clouds (C_L in sfc ob code) (0513)

CBH: height of cloud base ("h" in sfc ob code) (1600)

C2: types of middle layer clouds (C_M in sfc ob code) (0515)

C3: types of high clouds (C_H in sfc ob code) (0509)

IPRT: time period indicator for pressure tendency (see Appendix A, Table XII)

ICPR: characteristic of pressure tendency ("a" in sfc ob code) (0200)

PR: magnitude of pressure tendency (mb)

IQPR: quality control for pressure tendency (see Appendix A, Table IX)

TCA: total cloud amount (N in sfc ob code) (2700)

SCA(I),SCI(I),SCH(I): significant cloud amount (N_S, see 2700), significant cloud type (C, see 0500), significant cloud height (h_sh_s, see 1677); there are at most four levels of cloud information in this sequence

Type 3: Surface (Land and Ocean) Observations

These observations are taken at surface stations (ships, buoys, manual land stations, or automatic land stations). On the file, the land based observations come first, followed by the ocean based observations. Because extraneous alphanumeric characters are sometimes found in the elevation variable field in the ocean based observations (which should have a zero elevation), two different READ formats must be used to access the data on the Type 3 file:

For land based observations use

```
   READ(1,4)ALAT,ALON,IDA,IHR,IDSI,KPCI,EL,PZ,IQPZ,T,IQT,DPD,IQDPD,WD,WS,IQW,
            ITPPT,PT,TCA,WW,CLM,CBH,C1,C2,C3,IPRT,ICPR,PR,IQPR,(SCA(I),SCT(I),
            SCH(I),I=1,4)
 4 FORMAT(1X,2F6.2,3I2,I1,F4.0,F6.1,I1,F5.1,1X,I1,F5.1,1X,I1,2F4.0,1X,I1,I1,
          F4.1,7F2.0,/,1X,I1,I2,F3.1,I1,4(3F2.0))
```

For ocean based observations use

```
   READ(1,4)ALAT,ALON,IDA,IHR,IDSI,KPCI,EL,PZ,IQPZ,T,IQT,DPD,IQDPD,WD,WS,IQW,
            ITPPT,PT,TCA,WW,CLM,CBH,C1,C2,C3,IPRT,ICPR,PR,IQPR,(SCA(I),SCI(I),
            SCH(I),I=1,4)
 4 FORMAT(2F6.2,3I2,I1,A4,F6.1,I1,F5.1,1X,I1,F5.1,1X,I1,2F4.0,1X,I1,I1,F4.1,
          7F2.0,I1,I2,F3.1,I1,4(3F2.0))
```

The variables have the following definitions:

ALAT:	observation latitude to hundredths of a degree
ALON:	observation longitude to hundredths of a degree
IDA,IHR:	day and hour of the observation
IDSI:	data source index value (31-32 are land obs, 33-35 are ocean obs) (see Appendix A, Table I in FGGE-II formats documentation)
KPCI:	pressure code indicator; indicates the nature of the value stored in PZ (see Appendix A, Table X)

IDSI: data source index, specifies the device used to secure the observation (see Appendix A, Table I)

ITQC: indicator for type of quality check: 0=no quality check, 1=horizontal quality check made, 2=quality check against certain limits was made

P: pressure at flight altitude (nearest whole mb)

IQCP: quality control for pressure (see Appendix A, Table IV)

H: flight altitude (nearest whole meter)

IQCH: quality control on flight altitude (see Appendix A, Table IV)

T: temperature at flight altitude (nearest tenth of a °C)

IQCT: quality control on temperature (see Appendix A, Table IV)

TSIP: temperature at nearest standard isobaric pressure surface (nearest tenth of a °C)

HSIP: altitude at nearest standard isobaric pressure surface (meters)

NWR: number of wind observations included in the report

IORI: optional record indicator; 0=optional record not included, 1=included

ITW1: type indicator for first wind ob in record (0=spot, 1=mean, 9=unknown)

ALTW1: latitude (to tenths of a degree) of the first wind ob in record

ALNW1: longitude (to tenths of a degree) of the first wind ob in record

WD1 direction (degrees) of first wind ob in record

WS1: speed (ms^{-1}) of first wind ob in record

IQC1: quality control for first wind ob in record (see Appendix A, Table IV)

ITW1, ALTW2, ALNW2, WD2, WS2, IQC2: quantities corresponding to above for second wind ob in record

IWP: indicator for weather phenomena observed (see Appendix A, Table VII)

ICA: indicator for cloud amount, observed from base or top (see Appendix A, Table VIII)

HC: height of cloud, observed from base or top (meters)

Type 2: Aircraft Observations

These observations are single point observations taken by aircraft at a known pressure altitude above sea level. The following sequence of READ statements should be used to access the data for each aircraft observation on the file containing Type 2 data:

```
    READ(1,3)ALAT,ALON,IDA,IHR,IDSI,ITQC,P,IQCP,H,IQCH,T,IQCT,TSIP,HSIP,NWR,
             IORI
  3 FORMAT(1X,2F6.2,3I2,I1,1X,F4.0,I1,F5.0,1X,I1,F4.1,1X,I1,F4.1,F5.0,I2,I1)
```

The variable NWR contains the number of wind observations included. Since each wind observation record (that follows the above record) contains two individual observations, the total number of wind records is given by the FORTRAN statement NWREC=(NWR+1)/2. They assume the following form:

```
    DO 10 N=1,NWREC
    READ(1,4)ITW1,ALTW1,ALNW1,WD1,WS1,IQC1,ITW2,ALTW2,ALNW2,WD2,WS2,IQC2
  4 FORMAT(1X,2(I2,2F4.1,2F3.0,I1))
 10 CONTINUE
```

If IORI, the optional record indicator, has a value of zero, no record follows the wind records, and the end of the report has been reached. For IORI=1, the following record follows the wind records as the last record of the report:

```
    READ(1,5)IWP,ICA,HC
  5 FORMAT (1X,2I2,F5.0)
```

The variables have the following definitions:

ALAT: latitude of the current aircraft position (to hundredths of a degree)

ALON: longitude of the current aircraft position (to hundredths of a degree)

IDA,IHR: date and closest hour of the observation

WS: wind speed of the observation in meters/second

IQCW: quality control for wind values (see Appendix A, Table IV)

CC1,CC2 both variables have the values 99999, used to fill the record

CLOUD DATA RECORD (IDSI=75):

```
      READ(1,3)ALAT,ALON,IDA,IHR,IDSI,CLM,C1,CBH,C2,C3
    3 FORMAT (1X,2F6.2,3I2,40X,5F2.0)
```

The variables have the following definitions:

ALOT: observation latitude to hundredths of a degree

ALON: observation longitude to hundredths of a degree

IDA,IHR: day and closest hour of the observation

IDSI: for this type of record, IDSI=75 always

CLM: amount of low or middle level clouds (N_h) on code table 2700

C1: clouds of lower type (C_L) on code table 0513

CBH: cloud base height (h) on code table 1600

C2: clouds of middle type (C_M) on code table 0515

C3: clouds of high type (C_H) on code table 0509

If the user desires to use both types of data, use the read statement:

```
      READ(1,4)ALAT,ALON,IDA,IHR,IDSI,P,EL,ITYPE,Z,IQCZ,T,IQCT,DPD,IQCDPD,WD,WS,
               IQCW,CLM,C1,CBH,C2,C3
    4 FORMAT(1X,2F6.2,3I2,F5.1,F4.0,I2,F5.0,I2,F4.1,I2,F4.1,I2,2(1X,F3.0),
             I2,5F2.0)
```

where if IDSI=11,12,14,15,16,17, it would be known that CLM,C1,CBH,C2, and C3 would be filled with 9's, and

if IDSI=75, it would be known that P,EL,ITYPE,Z,IQCZ,T,IQCT,DPD,IQCDPD, WD,WS,IQCW would be filled with 9's.

Type 1: Upper-air Observations

These observations typically have the form of a sounding. Thus, for each observation there are several levels (usually at particular pressures) where the data are observed and reported. The following formatted READ should be used to access the data on the Type 1 file:

```
UPPER AIR DATA RECORD (IDSI=11,12,14,15,16,17):
READ(1,2)ALAT,ALON,IDA,IHR,IDSI,P,FL,ITYPE,Z,IQCZ,T,IQCT,DPD,IQCDPD,WD,WS,
        IQCW,CC1,CC2
  2 FORMAT(1X, 2F6.2, 3I2, F5.1, F4.0, I2, F5.0, I2, F4.1, I2, F4.1, I2, 2(1X,
        F3.0), I2, 2A5)
```

The variables have the following definitions:

ALAT: observation latitude to hundredths of a degree (southern hemisphere values are negative)

ALON: observation longitude to hundredths of a degree (in east long., 0° to 360°)

IDA, IHR: day and closest hour (24 hour clock) of the observation

IDSI: data source index value, specifies the type of sounding (rawinsonde, pilot balloon, etc.) (see Appendix A, Table I in FGGE II formats documentation)

P: pressure of the observation to tenths of mb

EL: elevation of the station above sea level in meters

ITYPE: type of level (standard, significant, etc.) (see Appendix A, Table III in FGGE II formats documentation)

Z: geopotential height of the observation in geopotential meters

IQCZ: quality control for geopotential height value (see Appendix A, Table IV)

T: temperature of the observation to tenths of °C

IQCT: quality control for temperature value (see Appendix A, Table IV)

DPD: dew point depression of the observation to tenths of °C

IQCPDP quality control for dew point depression value (see Appendix A, Table IV)

WD: wind direction of the observation in degrees

Appendix A(2): Structure of File Containing Data Extracted From FGGE II-B Data Tapes (Output File From BUFF)

Program BUFF, located on pfn=BUFFREADLS, id=NORQUIST, cy=2, creates a tape containing 10 files consisting of a header file and nine data files. The nine data files contain the FGGE II-B data for the date and time indicated in the header file. End-of-file marks follow each logical file on the tape.

The header file contains one record which should be read as follows:

```
READ(2,1)IMO,IDA,IYR,IHOUR
1 FORMAT (4I2).
```

This record is followed by an end-of-file mark, which is in turn followed by one data file for each of the following types of data in this order: Type 1, Type 2, Type 3, Type 4, Type 5, Type 6a, Type 6b, Type 7, Type 8. Each of these files is followed by an end-of-file mark. The various data types are described in the document "Formats for the International Exchange of Level II Data Sets During the FGGE" which is available for loan from the author. All references to appendices in the following data type descriptions are references to that document.

67	Statement Numbers	JDFI is the index of data type (01-08), so in order to process (output) a particular data type, the corresponding statement number in the "GO TO" should be the statement number of the proper "UNPACK" subroutine call. If a particular type of data is not desired, enter 25 for its statement label index in the "GO TO".

OUTPUT FILES:

TAPE2 Tape containing extracted FGGE II-B data [this file is explained in detail in Appendix A(2)].

WRITTEN OUTPUT:

1. JDSI, date, and times of any data records skipped over by value of constant in statement 36 of BUFF.
2. DSI (data source index), latitude, and longitude of observations copied for types 1,2,4 (these can be turned off in SUBROUTINE REPIDR by moving statement label 20 to the RETURN statement and commenting out the PRINT statement).
3. Indicators of end-of-file marks written to TAPE2 (note that besides the EOF marks indicated, an EOF mark is written after the date, time header record; see statements 15-17 in BUFF).
4. Latitude, longitude, and estimated terrain elevation of all satellite sounding observations rejected for being over land (this may be turned off in SUBROUTINE UNPACK4, statement 37).
5. Values of IREC, NREC1, and IT in SUBROUTINE UNPACK4 (turn off by moving label 99 to RETURN statement and commenting out PRINT* statement).

(NOTE: The values that are written to TAPE2 in each "UNPACK" subroutine may be printed out by removing comment indicators in column 1 from the appropriate print statement. Caution: if this is done for all data types, output will be very thick.)

INPUT FILES:

TAPE1 Copy of FGGE II-B data tape that excludes test files and header files (see "Formats for the International Exchange of Level II Data Sets During the FGGE").

TAPE10 144X73 grid values of terrain height from FGGE Fixed Field tape. Read as one binary record into TH(144,73), the values are arranged on 73 latitudes from 90°N to 90°S at 2.5° intervals, and for each latitude on 144 longitudes from 0°E (Greenwich) to 357.5°E at 2.5° intervals. Storage: pfn=TERHT144, id=NORQUIST, cy=1 (load from CC2467).

ITEMS REQUIRING CHANGE FOR DIFFERENT TIMES, RESOLUTIONS, ETC.:

LINE NUMBER(S)	VARIABLE OR CONSTANT	EXPLANATION
12	IYR	Last two digits of year of observation you want to extract
12	IMO	Month (1-12) of observation you want to extract
12	IDA	Date (1-31) of observation you want to extract
12	IHOUR	Hour (0-24) of observation you want to extract (present FGGE II-B tapes have observations at IHOUR=0,6,12,18 only)
36	7300	This statement allows the code to skip over any records preceding those for the time desired. The value used to replace 7300 can be estimated from runs extracting data from previous times on the tape (see "FINAL VALUE OF LOOP="). If no such runs have been done, set this value to 1.

Appendix A(1): Program BUFF

ABSTRACT: FGGE II B tape is used as input, and a restructured tape in unpacked, formatted form is output. All input values read from the tape are unpacked, but only selected values are written as output. This selection is based on what values are used by the surface pressure and upper air analyses except in the case of satellite soundings, in which all observations over land (determined by interpolating bilinearly terrain height from 2.5° lat.-lon. grid to observation location) are excluded from output tape, leaving only ocean based observations for use in the analysis procedure.

AFGL CYBER STORAGE:

BFRDLS/un=NORQUIS (RECLAIM from CC4830)

AFWL CRAY STORAGE:

None (code on AFGL Cyber only)

NOS CONTROL CARDS FOR AFGL CYBER:

```
NORQUIS,T=2000,CM=170000.
USER,NORQUIS,NORQUIS.
CHARGE,1049,6670.
LABEL,TAPE1,VSN=CC4925,NT,D=GE,F=SI,PO=R,R,L=COPYOFL27273.
GET,TAPE10=TRHT144.
DEFINE,TAPE2=F2B0412/CT=PU.
FTN,SL,R=3,PL=999999.
LGO.
GET,PRSFPR.
ROUTE,PRSFPR,DC=IN.
EOR
```

permanent files on the tape (the limit is 20 files), then catalog the output as one file. To get the desired program off this file, use the NOS/BE commands SKIPF to skip over any files before, then the COPYCF to a requested permanent file, and then catalogue that file. It can then be "acquired" for use on the Cray.

The codes described in the following appendices are described in the form used for the data assimilation experiment detailed by Halberstam et al. (1984). References to GER in the appendices refer to the technical report by Gerlach (1983),[8] while references to HJNT indicate the technical report by Halberstam et al. (1984).

---

8. Gerlach, A. M., ed., 1983: Objective Analysis and Prediction Techniques-1983. AFGL-TR-83-0333, Contract F19628-82-C-0023, Systems and Applied Sciences Corporation, ADA142441.

In this example, there are four files being used in sisin and sis, in which tape5 is the coded initialized field file, gsm is the forecast model output, tape6 is the coded corrections and analysis error file, and nm is the OI analysis output. In the second "cosmos" line above, citos is the copy routine, the record block size is set at 48 (this should not change), and four files are being copied to tape dnq<3>. In each "cosmos" run five minutes is allowed in this example. This CJXXX procedure is called by CJTAP, a procedure designed to run several cases of the procedure above sequentially. The form of CJTAP corresponding to the example of CJXXX given above is:

```
*select savelog=1844, printlog=logrun
*select printlog=hsp
*mass get cjxxx
*cosmos i=cjxxx with 0712 0800 001 / 7
*cosmos i=cjxxx with 0800 0812 002 / 7
*cosmos i=cjxxx with 0812 0900 003 / 7
.
.
.
```

so that, as before <1>=0712, <2>=0800, <3>=001 in the first "cosmos" for example.

Once the tapes containing the desired output files are written, they can be sent back by request (phone production control, AV 8-244-8195) and read at AFGL in formatted form using the following NOS control cards:

```
LABEL,TAPE1,VSN=tapename,NT,D=PE,F=S,PO=R,LB=KN.
FILE,TAPE1,BT=C,RT=F,FL=80.
```

It is important to note that the files will appear on the tape in exactly the same form as they were as individual coded files, and with end-of-file marks after each file. Incidentally, the sis and sisin procedures can be used to copy any coded file onto a tape, including program files. Thus, it is a convenient way to create a "backup" tape of one's programs. The procedure CJBCK, in mass storage under user=1844, is an example of storing several program files on tape. To retrieve the files from tape for later use, run the STOSI procedure on the AFWL Cyber with NOFILE set to the proper number of

PCC2: percent of effective cloud cover in second cloud layer (in percent)

P2: pressure at average cloud top of second cloud layer (mb)

TS: surface temperature (in °C)

PTROP: tropopause pressure (in mb)

TTROP: tropopause temperature (in °C)

QCTROP: index of accuracy for tropopause data (in mb)

NTYP1,NTYP2,NTYP3,NTYP4: number of layers reported for each of the respective observation types (see values of ITYP below for description of types)

ISCR: status of corrections to the observation (see Appendix A, Table XXXVII)

IQCI: quality control indicator (see Appendix A, Table XXXVIII)

IOP: logical record number of this record (always=2)

ITYP: indicator of type of sounding level; ITYP=01, layer thickness between reference pressure level and standard pressure level; ITYP=02, layer precipitable water, between a reference pressure level and a standard isobaric surface; ITYP=03, layer mean temperature between two non-standard pressure surfaces; ITYP=04, layer precipitable water between two non-standard pressure surfaces

The meanings of the remaining variables depend on the value of ITYP. They are summarized in the following table:

	ITYP=01	ITYP=02	ITYP=03	ITYP=04
QC1	objective thickness quality indicator (gpm)	index of accuracy for precipitable H_2O (%)	objective mean temp. quality indicator ($X10^{-1}$°C)	index of accuracy for precipitable H_2O(%)
PL1	pressure at reference level (mb)	pressure at reference level (mb)	pressure at lower level (mb)	pressure at lower level (mb)
PU1	pressure at standard pressure level (mb)	pressure at standard pressure level (mb)	pressure at upper level (mb)	pressure at upper level (mb)
V1	layer thickness ($X10^1$ gpm)	layer precipitable H_2O (mm)	layer mean temperature ($X10^{-1}$°C)	layer precipitable H_2O (mm)
QC2	objective thickness quality indicator (gpm)	index of accuracy for precipitable H_2O(%)	objective mean temp. quality indicator ($X10^{-1}$°C)	index of accuracy for precipitable H_2O(%)
PL2	pressure at reference level (mb)	pressure at reference level (mb)	pressure at lower level (mb)	pressure at lower level (mb)
PU2	pressure at standard pressure level (mb)	pressure at standard pressure level (mb)	pressure at upper level (mb)	pressure at upper level (mb)
V2	layer thickness ($X10^1$ gpm)	layer precipitable H_2O (mm)	layer mean temperature ($X10^{-1}$°C)	layer precipitable H_2O (mm)

Type 5: Satellite Clear Radiance Data

In the present version of the code, these data were not used because it was not known how they could be used in the global analysis. If a use can be determined for them, an UNPACK5 subroutine could be included in the BUFFREAD program. An end-of-file mark has been included as a place holder for the Type 5 data.

Type 6a: Satellite Temperature and Wind

These observations are single point observations taken by satellite. The records include observation values of temperature and wind speed and direction derived from cloud motion. The following formatted READ should be used to access data on the file containing Type 6a data values:

```
    READ(1,7)ALAT,ALON,IDA,IHR,IDSI,ITSWD,P,IQCP,IQC,T,WD,WS,IQCWD,IQCWS,OEVE,
   *         OEPE,IEHM,PDC,ICC,ISWFP
  7 FORMAT(1X,2F4.1,4I2,F3.0,2I1,3F3.0,2I1,2F2.0,2X,I1,F2.0,2I1)
```

The variables have the following definitions:

ALAT:	observation latitude to tenths of a degree
ALON:	observation longitude to tenths of a degree
IDA,IHR:	day and closest hour of the observation
IDSI:	data source index value, specifies the type of observation (see Appendix A, Table I)
ITSWD:	type of satellite wind derivation (see Appendix A, Table XXXIII)
P:	pressure (mb) at effective wind level
IQCP:	subjective pressure confidence factor (see Appendix A, Table XXX)
IQC:	quality control indicator for satellite winds (see Appendix A, Table XXXVI)
T:	temperature (°C)
WD:	wind direction (degrees)
WS:	wind speed (ms^{-1})
IQCWD:	subjective wind direction confidence factor (Appendix A, Table XXX)
IQCWS:	subjective wind speed confidence factor (Appendix A, Table XXX)
OEVE:	objective estimate of vector error (ms^{-1}) (99 used for unspecified)
OEPE:	objective estimate of pressure error ($X10^{1}$ mb) (99 used for unspecified)

IEHM: emissivity used in height measurement (see Appendix A, Table XXIX)

PDC: pressure difference between cloud top and effective wind level ($\times 10^{1}$ mb) (99 used for unspecified)

ICC: cloud classification (see Appendix A, Table XXXIV)

ISWFP: significant wind field point (see Appendix A, Table XXXV)

Type 6b: Satellite Sea Surface Temperature

These observations are single point observations of sea surface (water) temperature taken by satellite. The following formatted READ should be used to access the data on the Type 6b file:

```
   READ(1,8)ALAT1,ALON1,IDA,IHR1,IDSI,SST1,IQCSST1,ALAT2,ALON2,IHR2,SST2,
        IQCSST2
 8 FORMAT(1X,2F4.1,3I2,F4.1,I2,2F4.1,I2,F4.1,I2)
```

The variables have the following meanings:

JDFI:	data type (here, JDFI=6)
ALAT1:	latitude (to tenths of a degree) of the first observation in the record
ALON1:	longitude (to tenths of a degree) of the first observation in the record
IDA:	date for both observations in the record
IHR1:	hour (minutes are dropped)* of the first observation in the record
IDSI:	data source index value, specifies the type of observation (see Appendix A, Table I)
SST1:	sea surface temperature (°C) of first observation in the record
IQCSST1:	quality indicator of first sea surface temperature observation in the record (see Appendix A, Table XXVIII)
ALAT2:	latitude (to tenths of a degree) of the second observation in the record
ALON2:	longitude (to tenths of a degree) of the second observation in the record
IHR2:	hour (minutes are dropped)* of the second observation in the record
SST2:	sea surface temperature (°C) of the second observation in the record
IQCSST2:	quality indicator of second sea surface temperature observation in the record (see Appendix A, Table XXVIII)

*Minutes have been dropped from Type 6b.

Type 7: Oceanographic Data Observations

These observations are taken aboard ships on which oceanographic observations are being taken. The following READ statement should be used to access data from the Type 7 data file:

```
   READ(1,9)ALAT,ALON,IDA,IHR,IDSI,PS,T,TW,WD,WS,SST,ISSTI,PT,SOLRAD
  9 FORMAT (1X,2F6.2,3I2,F6.1,2F5.1,F3.0,F2.0,F5.1,I2,2F3.0)
```

The variables have the following definitions:

ALAT:	latitude of the observation to hundredths of a degree
ALON:	longitude of the observation to hundredths of a degree
IDA,IHR:	day and hour (minutes were rounded to nearest hour) of the observation
IDSI:	data source index value (see Appendix A, Table I)
PS:	sea level pressure (mb)
T:	surface air temperature (°C)
TW:	air wet-bulb temperature (°C)
WD:	surface wind direction (degrees)
WS:	surface wind speed (ms^{-1})
SST:	sea surface (water) temperature (°C)
ISSTI:	instrument used to measure sea surface temperature (see Appendix A, Table II)
PT:	precipitation (in units of 0.2 mm) that fell during 6 hour period preceding synoptic time
SOLRAD:	solar radiation ($X10^{-2}$ langleys/minute)

Type 8: Drifting Buoy Observations

These observations are taken by automatic sensors and recorders on buoys deployed to drift in the oceans. The following READ statement should be used to access data on the surface drifting buoy (Type 8) data file:

```
   READ(1,9)ALAT,ALON,IDA,IHR,IDSI,P,IQCP,T,IQCT,WD,WS,IQCW,IW,SST,IQCSST
 9 FORMAT(1X,2F6.2,3I2,F5.1,I1,F4.1,I1,2F3.0,I1,I2,F4.1,I1)
```

The variables have the following definitions:

ALAT:	latitude of drifting buoy to hundredths of a degree
ALON:	longitude of drifting buoy to hundredths of a degree
IDA,IHR:	day and closest hour of the observation
IDIS:	data source index value, specifies the type of sounding (see Appendix A, Table I)
P:	sea level pressure to tenths of a mb
IQCP:	quality control for sea level pressure (see Appendix A, Table IX)
T:	air temperature in °C
IQCT:	quality control for air temperature (see Appendix A, Table IX)
WD:	wind direction in degrees
WS:	wind speed in meters/second
IQCW:	quality control for wind values (see Appendix A, Table IX)
IW:	wind indicator (i_w in surface ob code, code table 1855)
SST:	sea surface (water) temperature (in °C)
IQCSST:	quality control for sea surface temperature (see Appendix A, Table IX)

Appendix B: Programs for the Construction of a FGGE III-A Analysis in Spectral Form on Model Sigma Levels

PROGRAM NAME: LVL3RTV

ABSTRACT: Using analyzed (FGGE III-A) heights and temperatures on mandatory levels (1000-300 mb) and the 144 x 73 grid (2.5° lat.-lon. grid) terrain heights, calculate the terrain surface pressure for the 144 x 73 grid using the GETPS routine (see Gerlach, 1983). Then every other longitude value (144→72) is interpolated linearly to 62 Gaussian latitudes (73→62) forming a 72 x 62 grid of terrain surface pressure values.

AFGL CYBER STORAGE:

RTVPS/un=NORQUIS (RECLAIM from CC4830)

AFWL CRAY STORAGE:

None (code on AFGL Cyber only)

NOS CONTROL CARDS FOR AFGL CYBER:

```
NORQUIS,CM=155000,T=64.
USER,NORQUIS,NORQUIS.
CHARGE,1049,6670.
FTN,SL,R=3.
LABEL,TAPE1,VSN=CC4919,NT,D=GE,F=SI,PO=R,R,L=COPYOFL27176.
GETP,TAPESYS.
LIBRARY,TAPESYS.
GET,TAPE3=TRHT144.
DEFINE,TAPE2=PZ7262.
LGO.
GET,RTVTUV.
ROUTE,RTVTUV,DC=IN.
EOR
```

INPUT FILES:

TAPE1 Copy of FGGE III-A data tape containing analyses of height, temperature, winds, and relative humidity on mandatory levels. The first three files on the original tape have been excluded from this copy tape (see "Formats for the International Exchange of Level III Data Sets During the FGGE").

TAPE3 Same as TAPE10 for Program BUFF [see Appendix A(1)].

ITEMS REQUIRING CHANGE FOR DIFFERENT TIMES, RESOLUTIONS, ETC.:

LINE NUMBER(S)	VARIABLE OR CONSTANT	EXPLANATION
2-3 2 (GLATS)	62	Number of Gaussian latitudes as an array size must be changed if another resolution is desired
3,35	72	Number of longitudes as an array size and as a value for LON must be changed if another resolution is desired (must divide evenly into 144)
33	KHALF	Number of Gaussian latitudes in each hemisphere
36	MDA	Date of month of desired analysis
37	MHR	Hour of desired analysis (analyses are at 12 hour intervals)

OUTPUT FILES:

TAPE2 Contains following two records: (1) 72 x 62 record of terrain surface pressure (cb), and (2) 72 x 62 record of terrain heights (m).

WRITTEN OUTPUT:

1. Record number, data type, surface type, level, date, hour, number of words, grid type of each set of data encountered on TAPE1.
2. Any parity errors or end-of-file marks encountered on TAPE1 will be indicated in the output.

PROGRAM NAME: LVL3RTV

ABSTRACT: This code extracts the 72 x 62 grid values of Z, T, u, v from the 144 x 73 grid on the mandatory levels (1000-50 mb), interpolates them to the 72 longitude, 62 Gaussian latitude grid, then uses PTOSIG routine (see Gerlach, 1983) to interpolate T, u, v to sigma layers.

AFGL CYBER STORAGE:

RTVTUV/un=NORQUIS (RECLAIM from CC4830)

AFWL CRAY STORAGE:

None (code on AFGL Cyber only)

NOS CONTROL CARDS FOR AFGL CYBER:

```
NORQUIS,CM=125000,T=10000.
USER,NORQUIS,NORQUIS.
CHARGE,1049,6670.
FTN,SL,R=3.
LABEL,TAPE1,VSN=CC4919,NT,D=GE,F=SI,PO=R,R,L=COPYOFL27176.
GETP,TAPESYS.
LIBRARY,TAPESYS.
ATTACH,TAPE4=PZ7262.
DEFINE,TAPE2=TUV7262.
LGO.
GET,RTVRH.
ROUTE,RTVRH,DC=IN.
EOR
```

INPUT FILES:

TAPE1 copy of FGGE III-A data tape.

TAPE4 output file (see TAPE2, above) from retrieval of 72 x 62 grid values of terrain surface pressure.

ITEMS REQUIRING CHANGE FOR DIFFERENT TIMES, RESOLUTIONS, ETC.:

LINE NUMBER(S)	VARIABLE OR CONSTANT	EXPLANATION
2,4,213 2(GLATS)	62	Number of Gaussian latitudes in the desired grid (in 213,+1)
4,49	72	Number of evenly spaced longitudes in the desired grid (must divide evenly into 144)
6,7 (T only), 10,43 2,3(PTOSIG)	12	Number of sigma layers desired (for SI and POH, +1; for T, second dimension must be $\geq$12; in PTOSIG,PO,POH,TBO,UBO,VBO only)
48,212,213	31	Number of Gaussian latitudes in each hemisphere
60-65	DEL	Sigma depth of each sigma layer (1=highest layer, KP=lowest layer)
50	MDA	Day of the month of the desired analysis
51	MHR	Hour of the desired analysis (analyses are at 12 hour intervals)

OUTPUT FILES:

TAPE2 Contains T, u, v values on KP sigma levels for a 72 x 62 (or whatever the values of LON and 2*KHALF are) grid. (Ordered by records of 36 words each, for a given latitude and sigma layer, 12 T's, 12 u's, 12 v's.)

WRITTEN OUTPUT:

1. Any parity errors or end-of-file marks encountered on TAPE1 will be indicated in the output.
2. Record number, data type, surface type, level, date, hour, number of words, grid type of each set of data encountered on TAPE1.
3. Mandatory level pressures, heights, temperatures, and winds from two selected points in the analysis, and sigma layer pressures, temperatures, and winds resulting from the vertical interpolation of these values.

PROGRAM NAME: LVL3RTV

ABSTRACT: This code extracts the 72 x 62 grid values of T and R.H. from the 144 x 73 grid on the six mandatory levels (1000-300 mb) where they are available. They are interpolated to 72 longitudes on 62 Gaussian latitudes. Values of R.H. for the upper six mandatory layers are calculated using a linear interpolation in $\ell n\, p$ between R.H. (300 mb) and (50/300)*R.H. (300 mb) at 50 mb. These mandatory level values are then interpolated linearly in $\ell n\, p$ to sigma layers.

AFGL CYBER STORATE:

RTVRH/un=NORQUIS (RECLAIM from CC4830)

AFWL CRAY STORAGE:

None (code on AFGL Cyber only)

NOS CONTROL CARDS FOR AFGL CYBER:

```
NORQUIS,CM=125000,T=512.
USER,NORQUIS,NORQUIS.
CHARGE,1049,6670.
FTN,SL,R=3,
LABEL,TAPE1,VSN=CC4919,NT,D=GE,F=SI,PO=R,R,L=COPYOFL27176.
GETP,TAPESYS.
LIBRARY,TAPESYS.
ATTACH,TAPE4=PZ7262.
DEFINE,TAPE2=RH7262.
LGO.
GET,RTVTUVQ.
ROUTE,RTVTUVQ,DC=IN.
EOR
```

INPUT FILES:

TAPE1 Copy of FGGE III-A data tape.

TAPE4 Output file from retrieval of 72 x 62 grid values of terrain surface pressure.

ITEMS REQUIRING CHANGE FOR DIFFERENT TIMES, RESOLUTIONS, ETC.:

LINE NUMBER(S)	VARIABLE OR CONSTANT	EXPLANATION
2-4	62	Number of Gaussian latitudes in the desired grid (in GLATS 40 should be 62 - doesn't affect results in this version)
4,48	72	Number of evenly spaced longitudes in the desired grid (must divide evenly into 144)
6 (TS only), 7, 9, 42 222 (first one only), 223, 233 2 (PTOSIG)	12	Number of sigma layers desired (for SI and POH, + 1; for TS, second dimension must be $\geq$12; in PTOSIG, QBO, PO, POH only)
47	31	Number of Gaussian latitudes in each hemisphere.
58-63	DEL	Sigma depth of each sigma layer (1=highest layer, KP=lowest layer)

OUTPUT FILES:

TAPE2 Contains R.H. values on KP sigma layers for a 72 x 62 (or whatever the values of LON and 2*KHALF are) grid. (Ordered by records of 12 words each, for a given latitude and sigma layer, 12 R.H.'s.)

WRITTEN OUTPUT:

Same as for LVL3RTV for T, u, v, except having R.H. as output.

Appendix E: The ASAP Codes

PROGRAM NAME: PRESP

ABSTRACT: This code takes the forecast spectral coefficients as input and (1) reconfigures them in the form of the output from program TESTLMN, and (2) converts them to grid point values of T, u, v, q on 12 sigma layers and p_{sfc}, all on 62 x 62 latitude longitude grid.

AFGL CYBER STORAGE:

PRSFPR/un=NORQUIS (RECLAIM from CC4830)

AFWL CRAY STORAGE:

Mass storage: prespoi

On backup tape CJBCK (AFWL CYBER): prespoi (fourteenth file)

NOS CONTROL CARDS FOR AFGL CYBER:

```
NORQUIS,T=512,CM=270000.
USER,NORQUIS,NORQUIS.
CHARGE,1049,6670.
FTN,SL,R=3,PL=30000.
ATTACH,TAPE1=GSM0412.
GET,TAPE5=GLTWT31.
DEFINE,TAPE2=SP0412/CT=PU.
DEFINE,TAPE4=GR0412/CT=PU.
GET,BIN=BINCFFT.
MAP,ON.
LOAD,BIN.
LGO.
GET,SFPRAN.
ROUTE,SFPRAN,DC=IN.
EOR
```

PROGRAM NAME: MAIN

ABSTRACT: The AFGL global spectral model (see Brenner et al., 1982[5]). The code inputs the initialized spectral coefficients and generates forecast spectral coefficients as output for the desired length of forecast.

AFGL CYBER STORAGE:

pfn=FFC, id=NORQUIST, cy=1 (load from CC2467; on CYBER for storage purposes only)

AFWL CRAY STORAGE:

Mass storage: ff (present set up for NTIME=30, a 12 hr forecast); on backup tape CJBCK (AFWL CYBER): ff (second file)

INPUT FILES:

TAPE8 Output from normal mode initialization (see output file from program GMAIN).

TAPE2 See Tung (1985), section on program GNM, FORTRAN Unit 16.

OUTPUT FILE:

TAPE7 Forecast spectral coefficients (same record structure as input TAPE8).

Appendix D: Normal Mode Initialization and Global Spectral Model

PROGRAM NAME: GMAIN

ABSTRACT: The Machenhauer non-linear normal mode initialization (see Ballish, 1980, and Gerlach, 1982[9]). The code inputs the uninitialized spectral coefficients (as output from program CONSPE, or for the first cycle, from ASTOGS), and for the desired number of iterations and vertical modes, performs the initialization of T, η, D, and p_{sfc}. These fields along with q and ϕ_{sfc} are output in the same format as they were input.

AFGL CYBER STORAGE:

pfn=GNMC, id=NORQUIST, cy=1 (load from CC2467; on CYBER for storage purposes only)

AFWL CRAY STORAGE:

Mass storage: gnm

On backup tape CJBCK (AFWL CYBER): gnm (nineth file)

INPUT FILES:

TAPE5, TAPE16, TAPE80 See Tung (1985),[10] section on program GNM, for further details.

TAPE18 Spectral coefficients of η, D, T, q, P_{sfc}, Φ_{sfc} (see output file for program ASTOGS).

OUTPUT FILE:

TAPE19 Initialized spectral coefficients for input to global spectral model (record structure is identical to input file TAPE18 (see output file for program ASTOGS)).

9. Gerlach, A. M., ed., 1982: Objective Analysis and Prediction Techniques. AFGL-TR-82-0294, Contract F19628-82-C-0023, Systems and Applied Sciences Corporation, ADA131465.

10. Tung, S.-L., 1985: Users Guide for Normal Mode Analysis Method of Global Data Assimilation. AFGL-TR-85-XXXX, Contract F19628-82-C-0023, Systems and Applied Sciences Corporation (in press).

```
*xpa / 3
*compact tape3 tape3
*compact tape6 tape6
*mass store tape3:sptedqpssl12n tape6:sp62sl12n8
*mass store output:paout
*switch tape4 tape99
*switch tape7 tape9
*switch tape1 tape88
*switch tape2 tape87
*switch tape3 tape1
*switch tape6 tape4
*switch tape98 tape7
*switch tape97 tape2
*destroy tape5
*switch tape96 tape5
*mass get tape10:estprer as:asap<2>
*cft i=as,b=asb
*ldr bin=(asb,bcfft),x=asx
*asx / 25
*compact tape6 tape6
*compact tape11 tape11
*compact output output
*mass store tape6:mmmcor<2> output:asout
*mass store tape11:coreae<2>
*switch tape4 tape79
*switch tape99 tape4
*switch tape2 tape78
*switch tape1 tape2
*switch tape6 tape1
*mass get post:postasapoi
*cft i=post,b=postb
*ldr bin=(postb,bcfft),x=postx
*postx / 10
*compact output output
*compact tape6 tape6
*mass store output:postout<2> tape6:mmin<2>
*destroy tape6
*destroy tape1
*destroy tape10
*destroy tape79
*destroy tape2
*destroy tape4
*destroy tape88
*destroy tape7
*destroy tape78
*destroy tape5
*destroy tape9
*destroy tape87
*destroy tape11
*goto
*err<2>:
```

Fig. C-1. CJREP Procedure (Cont.)

```
*select savelog=1844,printlog=log<2>
*interrupt on softwareerror to err<2>
*mass get ff tape5 tape80 tape16 gnm tape18:nmin<1>
*cft i=gnm,b=gnmb
*ldr bin=gnmb,x=gnmx
*gnmx / 4
*compact tape19 tape19
*switch tape19 tape8
*mass get tape2
*mass store tape8:init<1>
*cft i=ff,b=ffb
*ldr bin=ffb,x=ffx
*ffx / 10
*compact tape7 tape7
*mass store tape7:gsm<2>
*switch tape7 tape1
*destroy tape5
*destroy tape16
*destroy tape80
*destroy tape8
*destroy tape2
*destroy tape6
*destroy tape9
*mass get tape5:glatwgt31c ps:prespoi cfft
*cft i=cfft,b=bcfft
*cft i=ps,b=psb
*ldr bin=(psb,bcfft),x=psx
*psx / 5
*compact tape2 tape2
*compact tape4 tape4
*mass store tape2:sptedqpssl128 tape4:spgp62sl128 output:psout
*switch tape5 tape99
*destroy tape1
*switch tape2 tape1
*mass get sp:spx<2> tape7:glat62 tape2:fgge2<2>
*mass get tape6:terrsst31c tape5:tersst62
*cft i=sp,b=spb
*ldr bin=(spb,bcfft),x=spx
*spx / 15
*compact tape9 tape9
*mass store tape9:sfprscor8 output:spout
*mass get pa:preasap
*cft i=pa,b=bpa
*ldr bin=(bpa,bcfft),x=xpa
*destroy tape1
*switch tape4 tape1
*switch tape99 tape4
*switch tape7 tape98
*switch tape5 tape7
*switch tape2 tape97
*switch tape9 tape2
*switch tape6 tape96
```

Fig. C-1. CJREP Procedure

Appendix C: Procedures for Running Data Assimilation Cycles on the AFWL Cray Computer

I. CJREP: A Procedure for Running a Complete Cycle

Fig. C-1 is a listing of the procedure CJREP, in mass storage under user=1844 and also on backup tape CJBCK (the handwritten additions have been made to the existing procedure). This procedure automatically runs the sequence of codes that make up one assimilation cycle: gnm, ff, prespoi, spx, preasap, asapoi, postasapoi. The commands used in this procedure can be thought of as control cards for the Cray. The basic sequence that is repeated for each of the seven codes is: (1) the code and all input files are obtained (attached) from mass ("mass get"), (2) the code itself is compiled, and a binary file of the compiled code is formed ("cft,i="), (3) the binary file is loaded into an executable file (ℓdr, bin=), (4) the executable file is run, (5) all output files are compacted (this is necessary because sometimes longer files may exist in several parts), (6) output files are stored on mass ("mass store"), (7) files needed by the succeeding program have their logical file name "switched" to the proper one for that job, and (8) any logical files no longer needed are "destroyed".

II. DNQOI: A Procedure for Running a Sequence of Cycles

The following listing of the file DNQOI is given as an example of how CJREP can be called in sequence for several contiguous assimilation cycles:

```
*savelog=1844,printlog=logmstr
*mass get cjrep
*mass get cj09X
*cosmos cj09X with 0912 / 44
*cosmos i=cjrep with 0912 1000 / 88
*cosmos i=cjrep with 1000 1012 / 88
*cosmos i=cjrep with 1012 1100 / 88
*cosmos i=cjrep with 1100 1112 / 88
*cosmos i=cjrep with 1112 1200 / 88
```

By using the "submit" command (as explained in the text of this users guide) for the file DNQOI, part of a cycle (on cj09X) for the 9th at 00Z to the 9th at 12Z, and five complete 12h cycles following that one can be executed. As explained in the text, the starting and ending date-time code ddtt indicate which cycle is processed, so by adjusting these values and adding more or using fewer "cosmos" commands, the desired sequential cycles may be run.

```
      IF(NSK.EQ.0) GO TO 20
      DO 10 NSKP=1,NSK
   10 READ(1)
   20 READ(1) ((A(M,N,KV),M=1,MS),N=1,NS)
      IF(NSKPA.EQ.0) GO TO 40
      DO 30 NSKP=1,NSKPA
   30 READ(1)
   40 CONTINUE
      WRITE(3) A
   50 CONTINUE
      DO 60 NTAPE=1,2
      READ(NTAPE)((A(M,N,1),M=1,MS),N=1,NS)
      WRITE(3)((A(M,N,1),M=1,MS),N=1,NS)
   60 CONTINUE
      STOP
      END
```

OUTPUT FILE:

TAPE3 Spectral coefficients of η, D, T, q for 31 waves (0-30) and 12 sigma layers in the following form (each line below represents a record):

NSTEP, TIME, ITIME, IDATE

η(I=1,31; J=1,31; K=1,12)

D(I=1,31; J=1,31; K=1,12)

T(I=1,31; J=1,31; K=1,12)

q(I=1,31; J=1,31; K=1,12)

p_{sfc}(I=1,31; J=1,31) (this is ℓn of surface pressure)

Φ_{sfc}(I=1,31; J=1,31) (this is geopotential of the surface)

PROGRAM NAME: ASTOGS

PURPOSE: This code converts the spectral coefficients from the form of the output of program TESTLMN to the form required as input to the non-linear normal mode initialization. Also, spectral coefficients of model terrain height are added as the last record to the output file.

NOS CONTROL CARDS AND PROGRAM LISTING:

```
NORQUIS,CM=150000.
USER,NORQUIS,NORQUIS.
CHARGE,1049,6670.
FTN,SL,R=3.
ATTACH,TAPE1=F0613.
GET,TAPE9=TRSST31.
DEFINE,TAPE7=F3A0613/CT=PU.
LGO.
PURGE,F0613.
EOR
        PROGRAM ASTOGS(OUTPUT,TAPE2,TAPE2,TAPE3)
        COMPLEX A(31,31,12)
        DATA NSTEP,TIME,ITIME,IDATE/0,0.0,4H 00Z,8H 07JAN79/
        MS=31
        NS=31
        ML=12
        WRITE(3) NSTEP,TIME,ITIME,IDATE
        DO 50 NT=1,4
        IF(NT.EQ.1)NSK=1
        IF(NT.EQ.2)NSK=2
        IF(NT.EQ.3)NSK=0
        IF(NT.EQ.4)NSK=3
        NSKPA=3-NSK
        REWIND 1
        DO 40 K=1,ML
        KV=ML-K+1
```

TAPE4 31 records of the sine of the Gaussian latitudes from equator to pole, followed by 31 records of the corresponding Gaussian weights (all values are correct to 20 decimal places).

ITEMS REQUIRING CHANGE FOR DIFFERENT TIMES, RESOLUTIONS, ETC.:

LINE NUMBER(S)	VARIABLE OR CONSTANT	EXPLANATION
3, 13, 21	62	Number of Gaussian latitudes
2, 3, 21 2, 3 (FFT1)	72	Number of evenly-spaced longitudes
4, 5, 6, 21 2, 3 (LEGSUM) 2, 3 (LMN) 2 (FFT1) 2, 4 (PMNS)	31	Number of waves in the spectral rhomboidal truncation (32 = wave numbers 0 through 30; 32 = one + rhomboidal truncation)
9 4 (FFT1)	303	This value must be $\geq$4*MP+15
21	12	Number of sigma layers

OUTPUT FILE:

TAPE3 31 x 31 spectral coefficients of T, η, D, q, and p_{sfc} in the following form (each line below represents a record):

T(I=1,31; J=1,31; K=1
η(I=1,31; J=1,31; K=1)
D(I=1,31; J=1,31; K=1)
q(I=1,31; J=1,31; K=1
:
T(I=1,31; J=1,31; K=12)
η(I=1,31; J=1,31; K=12)
D(I=1,31; J=1,31; K=12)
q(I=1,31; J=1,31; K=12)
p_{sfc}(I=1,31; J=1,31)

WRITTEN OUTPUT: None

PROGRAM NAME: TESTLMN

ABSTRACT: This code converts gridded (72 x 62) fields of T, u, v, q on 12 sigma layers and converts them to spectral coefficients of T, η (absolute vorticity), D (divergence) and q, and does the same for natural log of surface pressure.

AFGL CYBER STORAGE:

GFTOSP/un=NORQUIS (RECLAIM from CC4830)

AFWL CRAY STORAGE:

None (code on AFGL Cyber only)

NOS CONTROL CARDS FOR AFGL CYBER:

```
NORQUIS,CM=120000,T=64.
USER,NORQUIS,NORQUIS.
CHARGE,1049,6670.
FTN,SL,R=3.
ATTACH,TAPE1=PZ7262.
ATTACH,TAPE2=TUVQ.
GET,TAPE4=GLTWT31.
DEFINE,TAPE3=F0613.
GET,A=BINCFFT.
LOAD,A.
LGO.
PURGE,PZ7262.
PURGE,TUVQ.
GET,ASTOGS,DC=IN.
EOR
```

INPUT FILES:

TAPE1 72 x 62 field of values of p_{sfc} from LVL3RTV (p_{sfc}).

TAPE2 72 x 62 field of values T, u, v, q for each of 12 sigma layers from RW.

ITEMS REQUIRING CHANGE FOR DIFFERENT TIMES, RESOLUTIONS, ETC.:

LINE NUMBER(S)	VARIABLE OR CONSTANT	EXPLANATION
2,35	62	Number of Gaussian latitudes
2,34	72	Number of evenly-spaced longitudes (must divide evenly into 144)
3,5,29	12	Number of sigma layers

OUTPUT FILE:

TAPE2 Contains 72 X 62 fields of T, u, v, R.H. on 12 sigma layers. Records are ordered: [T(72,62), u(72,62), v(72,62), q(72,62), K=1],...,[T(72,62), u(72,62), v(72,62), q(72,62), K=12]

WRITTEN OUTPUT: None

PROGRAM NAME: RW

ABSTRACT: This code reads input from code that makes 72 X 62 T, u, v, R.H. file and converts R.H. to specific humidity (q) using retrieved surface pressure, forming a file of 72 X 62 values of T, u, v, q for 12 sigma layers.

AFGL CYBER STORAGE:

RHTOQ/un=NORQUIS (RECLAIM from CC4830)

AFWL CRAY STORAGE:

None (code on AFGL Cyber only)

NOS CONTROL CARDS FOR AFGL CYBER

```
NORQUIS,CM=120000,T=16.
USER,NORQUIS,NORQUIS.
CHARGE,1049,6670.
FTN,SL,R=3.
ATTACH,TAPE1=TUVRH.
ATTACH,TAPE4=PZ7262.
DEFINE,TAPE2=TUVQ.
LGO.
PURGE,TUVRH.
GET,GPTOSP.
ROUTE,GPTOSP,DC=IN.
EOR
```

INPUT FILES:

TAPE1 Output from RW (T, u, v, R.H.).

TAPE4 Output file from retrieval of 72 X 62 grid values of terrain surface pressure.

ITEMS REQUIRING CHANGE FOR DIFFERENT TIMES, RESOLUTIONS, ETC.:

LINE NUMBER(S)	VARIABLE OR CONSTANT	EXPLANATION
2, 20-24	62	Number of Gaussian latitudes
2, 17, 21-24	72	Number of evenly-spaced longitudes (must divide evenly into 144)
7, 28	12	Number of sigma layers (for line 28, +1)

OUTPUT FILE:

TAPE2 Contains 72 x 62 fields of T, u, v, R.H. on 12 sigma layers. Records are ordered: [T(72, 62), u(72, 62), v (72, 62), R.H. (72, 62), K=1],...,[T(72, 62), u (72, 62), v (72, 62), R.H. (72, 62), K=12].

WRITTEN OUTPUT: None

PROGRAM NAME: RW

ABSTRACT: This code reads input from the code that retrieves T, u, v on 72 x 62 grid on sigma layers and from the code that retrieves R.H. on 72 x 62 grid on sigma layers and combines them into one file.

AFGL CYBER STORAGE:

RTVTUVQ/un=NORQUIS (RECLAIM from CC4830)

AFWL CRAY STORAGE:

None (code on AFGL Cyber only)

NOS CONTROL CARDS FOR AFGL CYBER:

```
NORQUIS,CM=100000,T=32.
USER,NORQUIS,NORQUIS.
CHARGE,1049,6670.
FTN,SL,R=3.
ATTACH,TAPE1=TUV7262.
ATTACH,TAPE3=RH7262.
DEFINE,TAPE2=TUVRH.
LGO.
PURGE,TUV7262.
PURGE,RH7262.
GET,RHTOQ.
ROUTE,RHTOQ,DC=IN.
EOR
```

INPUT FILES:

TAPE1 Output from LVL3RTV (T, u, v).
TAPE3 Output from LVL3RTV (R.H.).

INPUT FILES:

TAPE1 Output from global spectral model; spectral coefficients in format identical to the output from ASTOGS.

TAPE5 31 Gaussian latitudes (in sine of latitude) from equator to pole correct to 20 decimal places, followed by 31 Gaussian weights in same orientation and accuracy.

ITEMS REQUIRING CHANGE FOR DIFFERENT TIMES, RESOLUTIONS, ETC.:

LINE NUMBER(S)	VARIABLE OR CONSTANT	EXPLANATION
3-5,9,13,15,16,23,24 2,3 (LEGSUM) 2(FFT1) 2,4 (PMNS) 2-4,8 (SPTOGP) 2-4,7 (UMVM) 2(FCSTOP)	31 (and 32 when paired with 31)	Rhomboidal truncation (0-30 waves) for spectral coefficients (32 should be changed the same way as 31; in line 16, KHALF is number of Gaussian latitudes in each hemisphere
6,14,25 2,3 (REORD) 3 (FFT1) 7 (SPTOGP	62	Number of evenly-spaced longitudes in the analysis grid
26	NP	Number of Gaussian latitudes in the analysis grid
3,8,27 2,3 (REORD) 2,7 (SPTOGP) 2 (UMVM) 2 (FCSTOP)	12	Number of sigma layers
11 4 (FFT1)	263	Dimension of the array WSAVE (should be $\geq$4*MP+15)

OUTPUT FILES:

TAPE2 Forecast spectral coefficients in same format as output from TESTLMN.

TAPE4 62 x 62 x 12 grid values of T, u, v, q, and 62 x 62 grid values of p_{sfc} arranged as follows:

```
  DO 10 LAT=1,62
  DO 10 LON=1,62
  T(LAT,LON,K=1,12), U(LAT,LON,K=1,12), V(LAT,LON,K=1,12)
  q(LAT,LON,K=1,12), Psfc(LAT,LON)
10 CONTINUE
```

WRITTEN OUTPUT:

1. For the first two longitudes at each latitude, the lat. and lon. indices and surface pressure are printed out, followed by the 12 sigma layer values of grid point temperature, winds, and specific humidity.

PROGRAM NAME: SFPRS1

ABSTRACT: This code performs the univariate optimum interpolation (OI) analysis of terrain surface pressure over land, and a multivariate (with winds) OI analysis of surface pressure over oceans. For further discussion of the procedure, see Gerlach (1983).

AFGL CYBER STORAGE:

SFPRAN/un=NORQUIS (RECLAIM from CC4830)

AFWL CRAY STORAGE:

Mass storage: spx

On backup tape CJBCK (AFWL CYBER): spx (fifteenth file)

NOS CONTROL CARDS FOR AFGL CYBER:

```
NORQUIS,T=3000,CM-277777.
USER,NORQUIS,NORQUIS.
CHARGE,1049,6670.
FTN,SL,R=3,PL=30000.
ATTACH,TAPE1=SP0412.
GET,TAPE7=GLAT62.
ATTACH,TAPE2=F2B0412.
GET,TAPE6=TRSST31.
ATTACH,TAPE4=GR0412.
GET,TAPE5=TRSST62.
DEFINE,TAPE9=SFP0412/CT=PU.
LGO.
GET,PRASAP.
ROUTE,PRASAP,DC=IN.
EOR
```

INPUT FILES:

TAPE1 Output (TAPE2) from program PRESP (see above).

TAPE2 Output from program BUFF (see Appendix A; surface data only are used in this code, Types 3, 7, 8).

TAPE4 Output (TAPE4) from program PRESP (see above).

TAPE5 62 x 62 grid point values of terrain surface height (a second word on each record representing the corresponding sea surface temperature is not used).

TAPE6 31 x 31 spectral coefficients of terrain surface geopotential (a second record containing 31 x 31 spectral coefficients of sea surface temperature is not used).

TAPE7 62 Gaussian latitudes (sine of latitude) from South Pole to North Pole (one value per record).

ITEMS REQUIRING CHANGE FOR DIFFERENT TIMES, RESOLUTIONS, ETC.:

LINE NUMBER(S)	VARIABLE OR CONSTANT	EXPLANATION
25, 26, 43 2 (OBCALC) 2,4 (SPTOGPX) 2,4 (SPTOGPW) 2 (FFTGP) 2,3 (LEGSUM) 2,4 (PMNS) 2-4(UMVM)	31 (and 32 when paired with 31)	Rhomboidal truncation (0-30 waves) for spectral coefficients
29, 43 5 (OBCALC)	12	Number of sigma layers (and 13 when it appears with 12, as in array SI)
28, 42 (first ref.) 4 (OBCALC, first ref.) 8 (FLAGS, first ref.) 32 (SFPRS2, first ref.)	62	Number of evenly-spaced longitudes in analysis grid
28, 42 (second ref.) 4 (OBCALC, second ref.) 8 (FLAGS, second ref.) 32 (SFPRS2, second ref.)	62	Number of Gaussian latitudes in analysis grid

62-65	IMON,IDATE IYEAR,ITIME	Month (0-12), date (0-31), year (last two digits), and hour (0-23) of the analysis
56 31, 32 (SFPRS2) 2 (CHLSKY) 12, 13 (RECALC)	10	Maximum number of observations actually used to correct a grid point value

OUTPUT FILE:

TAPE9 62 x 62 record of corrected (analyzed) surface pressures.

WRITTEN OUTPUT:

1. Listing of all observations not used in the analysis because of missing data or wrong time.

2. Diagnostic prints of values of various parameters from flagging box ICB (see line number 20 in FLAGS).

3. Listing of box number, latitude, longitude, JDSI, p, u, v residuals, quality controls for p and winds, and model terrain height for all observations used in the analysis.

4. Listing of latitude index, latitude, longitude index, longitude, forecast pressure value, calculated correction, normalized analysis error, and number of observations used in the analysis of each grid point.

PROGRAM NAME: ADJVER

ABSTRACT: This program inputs the analyzed surface pressure and the grid point forecast values of T, u, v, q and interpolates (linearly in ln p) these values to the new (analyzed) pressure values of the sigma layers. It then converts each interpolated 62 x 62 field to 31 X 31 spectral coefficients, and then re-evaluates these back on the 62 x 62 grid.

AFGL CYBER STORAGE:

PRASAP/un=NORQUIS (RECLAIM from CC4830)

AFWL CRAY STORAGE:

Mass storage: preasap

On backup tape CJBCK (AFWL CYBER): preasap (thirteenth file)

NOS CONTROL CARDS FOR AFGL CYBER:

```
NORQUIS,T=1000,CM=277777.
USER,NORQUIS,NORQUIS.
CHARGE,1049,6670.
FTN,SL,R=3,PL=50000.
ATTACH,TAPE1=GR0412.
ATTACH,TAPE2=SFP0412.
GET,TAPE4=GLTWT31.
DEFINE,TAPE3=SPN0412/CT-PU.
DEFINE,TAPE6=GRN0412/CT=PU.
GET,BIN=BINCFFT.
LOAD,BIN.
LGO.
GET,ASPRAN.
ROUTE,ASPRAN,DC=IN.
EOR
```

INPUT FILES:

TAPE1 Output (TAPE2) from program PRESP (see above).

TAPE2 Output (TAPE9) from program SFPRS1 (see above).

TAPE4 31 Gaussian latitudes (sine of latitude) from equator to pole, to 20 decimal places, followed by 31 Gaussian weights in same orientation and accuracy.

ITEMS REQUIRING CHANGE FOR DIFFERENT TIMES, RESOLUTIONS, ETC.:

LINE NUMBER(S)	VARIABLE OR CONSTANT	EXPLANATION
10, 11 (first ref.), 14 (first ref.), 50 2,3(FFT1) 8(SPTOGPG) 2,4(REORD) 7(SPTOGP)	62	Number of evenly-spaced longitudes in the analysis grid
11 (second ref.), 14 (second ref.), 28, 51	62	Number of Gaussian latitudes in the analysis grid
12-14,19,48,49 2,3(LEGSUM,GQL,LMN) 2(FFT1); 2,4(PMNS) 2(PRINT); 3-5,10,15,16 (SPTOGPG); 2-4, 8(SPTOGP) 2-4, 7(UMVM)	31 (and 32 when paired with 31)	Rhomboidal truncation for spectral coefficients (0-30 waves)
10,12,22,52 2(LNPINTP) 3,8(SPTOGPG) 2-4(REORD) 2,7(SPTOGP)	12	Number of sigma layers (and 13 when it appears with 12, as in the array SI)
16	DEL	Sigma layer depths (surface to top)
38	NOVRINT	Switch to allow (0) or turn off (1) vertical interpolation to new sigma layer pressures

OUTPUT FILES:

TAPE3 Spectral coefficients of T, η, D, q and p_{sfc} after T, u, v, q grid fields were vertically interpolated to new sigma layer pressures.

TAPE6 62 x 62 x 12 grid values of T, u, v, q and 62 x 62 values for p_{sfc} from evaluation of spectral values on TAPE3.

WRITTEN OUTPUT:

1. Sample output from subroutine LNPINTP for T, u, v, q at two selected grid points.

2. List of sines of Gaussian latitudes.

3. For the first two longitudes at each latitude, the lat. and lon. indices and surface pressure are printed out, followed by the 12 sigma layer values of grid point T, u, v, q.

PROGRAM NAME: ASAP1

ABSTRACT: This code calculates level Z and layer u, v, q residuals using spectral coefficients of T, η, D, q on new sigma layer pressures and upper air observations (Types 1, 2, 4, 6a). It then performs a multivariate OI analysis for Z, u, v on sigma layers and a univariate OI analysis for q on sigma layers.

AFGL CYBER STORAGE:

ASPRAN/un=NORQUIS (RECLAIM from CC4830)

AFWL CRAY STORAGE:

Mass storage: asapoi
On backup tape CJBCK (AFWL CYBER): asapoi (seventeenth file)

NOS CONTROL CARDS FOR AFGL CYBER:

```
NORQUIS,T=6000,CM=305000.
USER,NORQUIS,NORQUIS.
CHARGE,1049,6670.
FTN,SL,R=3,PL=99999.
ATTACH,TAPE1=SPN0412.
GET,TAPE7=GLAT62.
ATTACH,TAPE2=F2B0412.
GET,TAPE5=TRSST31.
GET,TAPE10=ESPRER.
ATTACH,TAPE4=GRN0412.
DEFINE,TAPE6=MMM0412/CT=PU.
DEFINE,TAPE11=CE0412/CT=PU.
MAP,ON.
LGO.
GET,PSTASAP.
ROUTE,PSTASAP,DC=IN.
EOR
```

INPUT FILES:

TAPE1 Output (TAPE3) from program ADJVER (see above).

TAPE2 Output from program BUFF (see Appendix A; upper-air data only are used in this code, Types 1, 2, 4, 6a).

TAPE4 Output (TAPE6) from program ADJVER (see above).

TAPE5 31 x 31 spectral coefficients of terrain surface geopotential (a second record containing 31 x 31 spectral coefficients of sea surface temperature is not used).

TAPE7 62 Gaussian latitudes (sine of latitude) from South Pole to North Pole (one value per record).

TAPE10 Estimated prediction error values for Z, u, v, q on 12 mandatory levels (100-50 mb). Records are structured: Z(1,12); u(1,12); v(1,12); q(1,12); one record for each Gaussian latitude.

ITEMS REQUIRING CHANGE FOR DIFFERENT TIMES, RESOLUTIONS, ETC.:

LINE NUMBER(S)	VARIABLE OR CONSTANT	EXPLANATION
21,22,42,125,126,129,130 4(MASTOR1,MASTOR2) 4,5(MASTOR6) 3,4(FG); 2,4(SPTOGPX, SPTOGPW); 2(FFTGP) 2,3(LEGSUM); 2,4(PMNS) 2-4(UMVM)	31 (and 32 when paired with 32)	Rhomboidal truncation for spectral coefficients (0-30 waves)
41 (first ref.)	62	Number of evenly-spaced longitudes in the analysis grid
41 (second ref.)	62	Number of Gaussian latitudes in the analysis grid

21,22,24,25,28,29,33,34 40,62,80; 2,3; 8-10 (MASTOR1); 2,3,6-8 (MASTOR4); 16,18,19 (QCALC); 2,4,5(OBTMZL); 2,3,4,9-11(MASTOR2); 2,3,5,11-13(MASTOR6); 2-4,6(CALCRES);3,4,6,7, 11,12(FLAGS); 2,3,5,6(FG); 2-4(PTOSIG); 20(TLAZLE); 23-26,28,30, 31,33(ASAP2); 2,4,7,11 (QCOR); 2-5(LOWTMP); 11(ESOBER)	12	Number of sigma layers (and 13 when it appears with 12, as in array SIO
25(ASAP1); 3,5(LOWTMP)	25	Equal to 2*ML+1, where ML is the number of sigma layers
28,109(ASAP; 10(MASTOR1); 8(MASTOR4); 19(QCALC); 5(OBTMZL); 11(MASTOR2); 13(MASTOR6); 6(CALCRES); 12(FLAGS); 6(FG); 33(ASAP2)	85	Equal to 7*ML+1
23,37,107(ASAP1); 23-28,40(ASAP2); 2-6(QCOR)	8 (also, 96)	NSNDS, the maximum number of complete soundings that are considered for contributing to the correction of a particular grid point (96=ML*NSNDS)
108(ASAP1); 27,28 (first ref. only), 29,30(ASAP2); 2,6,7(QCOR); 2(CHLSKY); 12,13(RECALC)	10 (also, 20)	NLRHS, the maximum number of individual height or wind observations actually used to correct a grid point value (if all observations were winds, there would be 20, 10 u's and 10 v's)
114-117	IMON,IDATE, IYR,ITIME	Month (0-12, date (0-31), year (last two digits), and hour (0-23) of the analysis

<u>OUTPUT FILES</u>:

TAPE6 62 x 62 x 12 corrected (analyzed) values of T, u, v, q in the following form:

```
     DO 140 LAT=1,62
     DO 140 LON=1,62
140  WRITE(6)(T(K),K=1,12), (U(K),K=1,12), (V(K),K=1,12),
     (Q(K),K=1,12)
```

TAPE11 Calculated corrections Z_c, U_c, V_c, Q_c and estimated analysis errors, Z_E, U_E, V_E, Q_E on 62 x 62 x 12 grid, output in the following manner:

```
    DO 140 LAT=1,62
    DO 140 LON=1,62
140 WRITE(11) (Zc(K),K=1,12), (Uc(K),K=1,12),
    (Vc(k),K=1,12), (Qc(K),K=1,12), (ZE(K),K=1,12),
    (UE(K),K=1,12), (VE(K),K=1,12), (QE(K),K=1,12)
```

<u>WRITTEN OUTPUT</u>:

1. Number of observations (NUM) and timings (SCND) from each of the MASTORE subroutines that calculate the residuals.

2. Diagnostic prints of values of various parameters from flagging box ICB (see line number 43 in FLAGS).

3. Listing of latitude index, latitude, longitude index, longitude, forecast value, calculated correction, normalized analysis error, and number of observations used in the analysis of each variable of grid points LAT=1,61, LON=1.

4. Listing of box number, latitude, longitude, JDSI, and Z, u, v, q residuals and quality controls for every fiftieth observation.

5. Listing of all pressure levels and layers, and all Z, u, v, q residuals and quality controls that were collected around grid points LAT=38 and LON=55,62.

PROGRAM NAME: CONSPE

ABSTRACT: This program takes the 62 x 62 grid values of T, u, v, q at 12 sigma layers and p_{sfc} which were corrected by means of the OI analysis and expands them into spectral components for the AFGL global spectral model.

AFGL CYBER STORAGE:

PSTASAP/un=NORQUIS (RECLAIM from CC4830)

AFWL CRAY STORAGE:

Mass storage: postasapoi
On backup tape CJBCK (AFWL CYBER): postasapoi (sixteenth file)

NOS CONTROL CARDS FOR AFGL CYBER:

```
NORQUIS,T=1000,CM=260000.
USER,NORQUIS,NORQUIS.
CHARGE,1049,6670.
FTN,SL,R=3.
ATTACH,TAPE1=MMM0412.
ATTACH,TAPE2=SPN0412.
GET,TAPE4=GLTWT31.
GET,TAPE5=TRSST31.
DEFINE,TAPE6=ANL0412/CT=PU.
GET,BIN=BINCFFT.
LOAD,BIN.
LGO.
EOR
```

INPUT FILES:

TAPE1 Output (TAPE6) from program ASAP1 (see above).

TAPE2 Output (TAPE6) from program ADJVER (see above).

TAPE4 31 Gaussian latitudes (sine of latitude) from equator to pole, to 20 decimal places, followed by 31 Gaussian weights in same orientation and accuracy.

ITEMS REQUIRING CHANGE FOR DIFFERENT TIMES, RESOLUTIONS, ETC.:

LINE NUMBER(S)	VARIABLE OR CONSTANT	EXPLANATION
8,9(first index), 31; 2,3(FFT1)	62	Number of evenly-spaced longitudes in the analysis grid
9 (second index), 21,62.	62	Number of Gaussian latitudes in the analysis grid
10-12, 29-30; 2,3(LEG-SUM,GQL,LMN), 2(FFT1), 2,4(PMNS), 2(PRINT, FGSHIFT)	31 (and 32 when paired with 32)	Rhomboidal truncation for spectral coefficients (0-30 waves)
10,12,22,33; 2,3(FGSHIFT) 2(RMSC)	12	Number of sigma layers
14, 4(FFT1)	263	Dimension of work array WSAVE (must be $\geq$ 4*MP+15)
5(FGSHIFT)	DEL	Sigma thickness of layers

OUTPUT FILES:

TAPE6 31 x 31 spectral coefficients of analyzed η, D, T, q on 12 sigma layers, analyzed p_{sfc}, and ϕ_{sfc} in the form of the output from program ASTOGS (see Appendix B).

WRITTEN OUTPUT:

1. Root mean square values computed from spectral coefficients of analyzed η, D, T, q, and p_{sfc}. Values computed for η, D, T, q are for all layers, and for a weighted average of all layers.

END

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